ECL 260

THE McGUIRE REACTOR: A CASE STUDY IN NUCLEAR REACTOR LICENSING

I. K. FONG

This case describes the efforts by Duke Power Company to obtain an operating license for a nuclear power plant in the aftermath of the Three Mile Island accident. Particular focus is placed on the difficulties encountered in meeting MRC's new design requirements for control of accidental hydrogen generation.

A Case Prepared Under the WISE Program

ECL 260

Educating Prospective Engineers for Public Policy

THE McGUIRE REACTOR: A CASE STUDY IN NUCLEAR REACTOR LICENSING

by

Ivan Kenneth Fong[1]

January 1985

Prepared as part of the 1982 Washington Internships for Students of Engineering (WISE) Program under the supervision of Dr. Karl Willenbrock,[2] 1982 WISE Faculty-Member-in-Residence, and edited by Dr. Barry Hyman.[3] This work was supported by NSF Grant SED 7918984. All opinions presented are those of the author and do not in any way represent those of NSF, the author's institution, or of individuals or other institutions referred to in the text.

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ACKNOWLEDGEMENTS

This case study evolved from my participation in the Washington Internships for Students of Engineering (WISE) program -- a ten-week summer internship for fifteen senior engineering students to study the interaction between engineering and public policy and to explore the role of scientist and enginners in setting national policy. My deepest appreciation goes to Professor F. Karl Willenbrock, faculty-member-in-residence of the 1982 WISE program, for his unending inspiration and advice during the research and writing of this case. The case also formed the basis for my undergraduate thesis at M.I.T.

I am also grateful to Duke Power Company for providing help, information, and hospitality during my visit to Charlotte, North Carolina, last summer. In particular, I would like to thank Carol Barrett, Skip Copp, Michael Funderburke, Frank Jenkins, Ira Kaplan, Richard Michael, and Pat Tate, for their invaluable aid and cooperation in support of my case study research.

My sincere thanks also go to Ralph Birkel, John Larkin, Carl Stahl, Charles Tinkler, and Particia Worthington of the Nuclear Regulatory Commission for their comments and insights concerning the technical and regulatory particulars of this case. In addition, the reference librarians at the NRC Public Document Room deserve a note of special thanks for their help in the retrieval of key documents used in the preparation of this paper.

If there is one thing I learned last summer, it is the importance of getting information from the right people. For this reason, I thank David Jeng and Lawrence Shao of the NRC and Carolyn Heising of MIT's Department of Nuclear Engineering for their unselfish assistance during the limited time-frame of the internship.

Finally, I would like to acknowledge the support of Barry Hyman, Director of the WISE program; the American Nuclear Society, and my advisor, Dr. C. Michael Mohr. Gail Marcus, of the ANS, and Bob Civiak, her colleague, at the Congressional Research Service, together with John Graham, ANS's Washington representative, provided the initial guidance in selecting the topic of this case study. Dr. Mohr, a gifted lecturer and outstanding advisor, provided the comments and suggestions which led to the final version of this thesis. No thesis would be complete without a word of thanks to the friends and family members who provide their inexhaustible moral support. Special thanks go to Paul Gabuzda, Max Hailperin, Omar Valerio, and Clark Santos, for all they have done.

Any errors contained herein, of course, remain the responsibility of the author.

INTRODUCTION

The March 1979 accident at the Three Mile Island-Unit 2 (TMI-2) nuclear plant near Harrisburg, Pennsylvania, catalyzed the nation's public and the nuclear industry to reconsider serious questions regarding safety of U.S. commercial nuclear power plants. More importantly, the accident at TMI-2 focused public attention on the risks of nuclear power and the role of the Nuclear Regulatory Commission (NRC) in reactor licensing.

This case study is an attempt to illustrate this focus by examining the events which led to the NRC's issuance of an operating license to Duke Power Company for the McGuire Nuclear Station. The case is noteworthy for two reasons:

(a) The McGuire case was the first contested operating license approved by the NRC after the accident at TMI-2; and

(b) The basis for opposition was an engineering design safety issue that arose as a result of the TMI-2 accident, namely, the hydrogen control issue.

During the accident at TMI-2, hydrogen gas was generated in excess of amounts allowed in existing NRC regulations to be considered in the design and accident analysis of light-water reactor (LWR) nuclear power plants. The entwining technical and policy aspects of the hydrogen control issue dominated the last few months of the licensing of McGuire during the spring and summer of 1981 -- those conflicts, and their resolutions, form the heart of this case history.

The McGuire Nuclear Station

The William B. McGuire Nuclear Station is located on the southern shore of scenic Lake Norman near the Cowens Ford Dam in the northwestern portion of Mecklenburg County, North Carolina, approximately 17 miles north-northwest of Charlotte, North Carolina.

The two identical units, each of which has a thermal power level of 3411 Mw, utilize a pressurized-water reactor (PWR) as the nuclear steam supply system (NSSS), a four-loop borated water reactor coolant system, and a containment system utilizing the ice condenser pressure suppression concept.

In an ice condenser containment, an annual space between a steel liner and the outer concrete building is constructed and filled with cells of refrigerated borated ice. (Exhibit 1). In the event of a loss of coolant accident (LOCA), condensation of the released steam by the ice would limit the pressure in the containment. Consequently,

the containment structure can be designed for a lesser pressure and can have a smaller volume than a conventional PWR containment building.

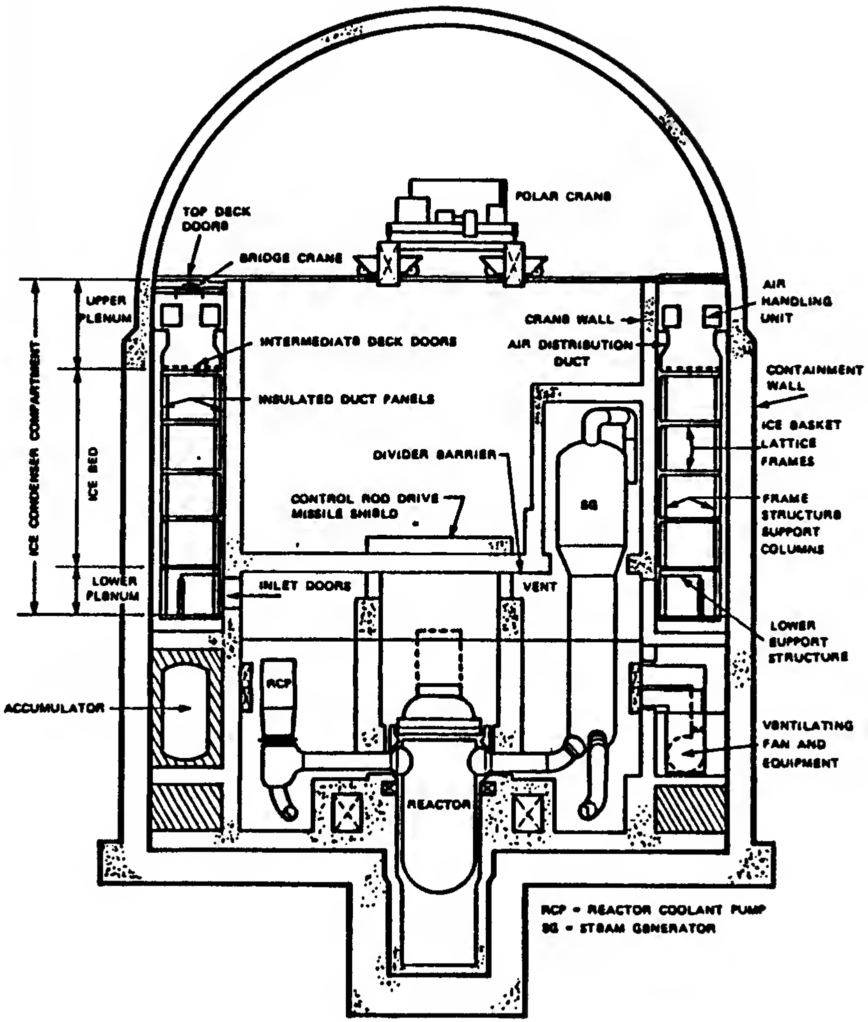
The McGuire NSSS and turbine generators were manufactured by Westinghouse. The plant was designed and constructed by its owner, Duke Power Company. The original 1970 cost estimate was $372 million -- Duke now estimates the cost of the total plant to be $1.955 billion.

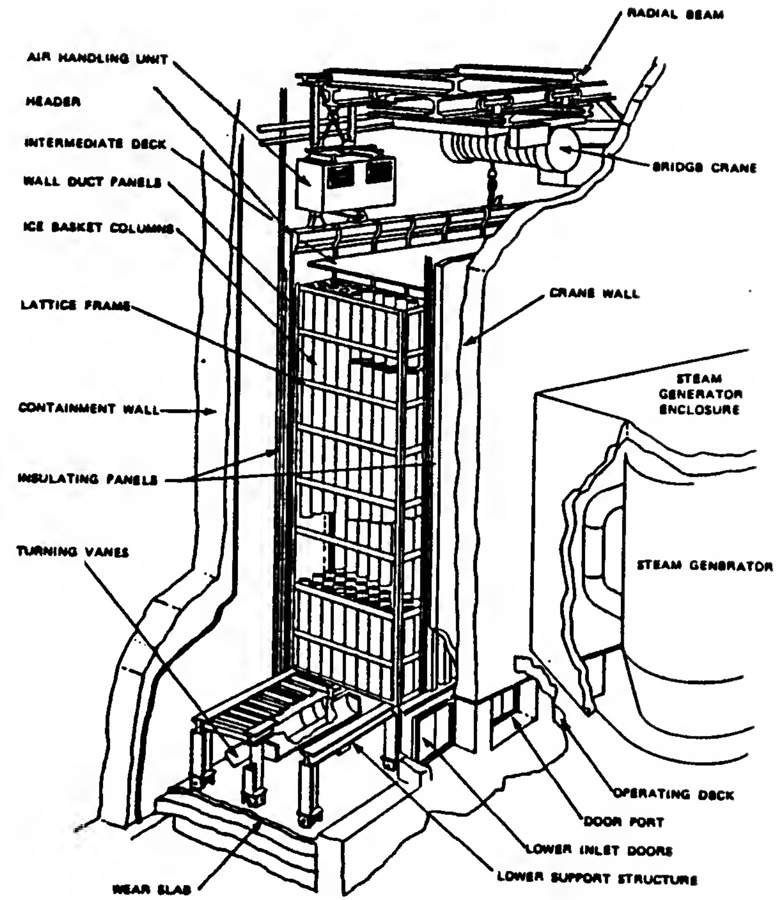
From the Drawing Board

The case history has its beginnings in September 1970, when Duke filed an application with the NRC (then the Atomic Energy Commission) for licenses to construct its proposed McGuire Nuclear Station, Units 1 and 2. After the Commission staff reviewed the application in a Safety Evaluation Report (SER) dated December 3, 1971, and subsequently issued numerous supplement SER's in January and June of 1972, public hearings were held before an NRC Atomic Safety and Licensing Board (ASLB) in Charlotte, North Carolina, during the fall of 1972. During these public hearings, an anti-nuclear group, the Carolina Environmental Study Group, was strong in its opposition to construction and operation of the plant. Despite the citizen group's organization, the NRC issued Construction Permit Nos. CPPR-83 and CPPR-84 for Units 1 and 2 respectively, on February 28, 1973.

On April 4, 1974, Duke Power officials tendered a combined application for operating licenses for both units of McGuire, and on June 7, 1974, the NRC, after informing Duke that its application was complete, reviewed and docketed the operating licenses for McGuire. The application specified a core thermal power level of 3411 megawatts for each unit; the corresponding net electrical power output is approximately 1180 megawatts for each reactor.

The second set of public hearings was held in 1977 and 1978 -- again the environmentalists were vocal in their opposition. On March 1, 1978, the NRC staff issued an operating license application SER. As construction at the site neared completion, Duke kept in touch with the licensing status of McGuire through NRC staffer Ralph Birkel, who began as Project Manager for McGuire in 1978. Birkel, of the Office of Nuclear Reactor Regulation's Division of Licensing, was a chemical engineer by training with over 20 years of NRC experience and served as the liason between the utility and the regulatory agency.





Cutaway View of Ice Condenser

Exhibit 1

PWR Ice Condenser Containment

PART A: NRC RESPONSE TO TMI-2

The accident on March 28, 1979 at TMI-2 was caused by a combination of operator error and equipment failure which resulted in substantial damage to reactor fuel cladding. Hydrogen gas, generated from reaction of heated zircaloy cladding with steam, accumulated to levels in the containment structure that caused a potentially dangerous pressure increase.

The incident at Three Mile Island raised more than eyebrows at the NRC. Seemingly caught by surprise, the Commission, as well as nuclear power plant utilities around the nation, focused attention on the events which led to the nuclear accident and on schemes which could prevent another "TMI-type" accident. The NRC needed to thoroughly analyze the accident sequence and to study the appropriate regulatory responses; while Duke Power Company needed to reassess McGuire's fundamental design capabilities and to continue to push for its long awaited operating license.

Immediately following the TMI-2 accident, the NRC began a phase of investigation and study that dominated a large portion of its resources. Agency priorities were reset and for almost a year after the March 1979 accident, emphasis was taken off licensing activities and put on finding deficiencies in the regulatory process and in the design and operation of nuclear powerplants. (1) The NRC created several task forces and special studies specifically charged to recommend changes not only in reactor designs and operations but also in the regulatory process and management structure of the NRC.

The Hydrogen Problem

One of the NRC's concerns was that raised by the generation of hydrogen gas from the cladding-steam reaction well in excess of the existing design basis. Pressure loads from combustion of hydrogen, as demonstrated at TMI-2, could threaten containment integrity or damage important safety-related equipment.

(1) "Three Mile Island: The Most Studied Nuclear Accident in History," EMD-80-109, General Accounting Office, Washington, D.C., September 1980, p. 53.

The particular danger of hydrogen flammability or detonation in PWR's can be seen from Exhibit A-1. The conservative estimates of vol% hydrogen in containment can be compared with the flammability limits presented in Exhibit A-2 to determine the likelihood of flammability, given the containment composition. Note that hydrogen in steam-free air can be expected to burn at concentration from 4 to 18 vol% and detonate above 18 vol%, and that there is little effect on the lower flammability limit at low steam concentrations. Flammability limits also depend on the pressure, temperature, and direction of the flame.

In July 1979, the TMI-2 Lessons Learned Task Force issued its Status Report and Short-Term Recommendations (NUREG-0578) which outlined three "short-term" recommendations regarding post-accident hydrogen control systems for PWR and boiling-water reactor (BWR) containments:

(a) Provide dedicated penetrations for external recombiner or post-accident external purge systems;

(b) Require inerting of BWR containments; and

(c) Provide capability to install hydrogen recombiners at each LWR (as part of the long-term reconsideration of the design basis for combustible gas control systems).

Since the immediate concern was the adequacy of reactor protection against burns or explosions of hydrogen gas which may be generated during an accident, inerting the containment, i.e., keeping it filled with an inert gas (such as nitrogen) during reactor operation, was a prime solution to the problem.

For LWR's, hydrogen recombiners would serve to keep the concentration of small amounts of hydrogen generated below the limit for which it might combust.

Senior Fellow of the Advisory Committee on Reactor Safeguards (ACRS) William Kastenberg responded to the Status Report in an October 3, 1979 report discussing the hydrogen design basis, the potential implications of the TMI-2 hydrogen generation on design basis accidents in general, and the implications for future licensing and safety analysis (ice condenser plants, in particular). After a brief discussion of various hydrogen control systems, Kastenberg concluded that while it was premature to recommend any of the potential options for ice condenser plants, a short term consideration should be given to inerting ice condenser containments. Kastenberg acknowledged, nonetheless, the negative aspects of inerting ice condenser containments which related to access and cost.

In addition, "for the long term, research should be carried out on the use of chemical additives in conjunction with the containment spray system and in the use of filtered vented containment. The use of containment spray has the advantage that the system is already in place. Vented containment has the advantage that it can potentially cope with other sources of containment failure," Kastenberg added.

Shortly thereafter, the TMI-2 Lessons Learned Task Force published its Final Report (NUREG-0585, October, 1979) in which the Task Force recommended that the Commission "issue within three months a notice of intent to conduct rulemaking to solicit comments on the issues and facts relating to the consideration of design features to mitigate accidents that would result in (a) core-melt, and (b) severe core damage, but not substantial melting." In particular, the Task Force indicated that the focus of the rulemaking procedure would be consideration of employment of controlled, filtered venting for core-melt accidents and provisions to cope with hydrogen generation beyond the design basis.

The rationale for rulemaking arose from the realization that core-melt accidents are the most significant -- in terms of public risk -- of the events not included in the design basis. Although these accidents have a lower frequency than design basis accidents, their potential consequences still make them risk-significant. From the accident sequence point of view, it is the potential failure of containment which yields this high risk. Hence the prevention of containment failure, which could be accomplished with filtered venting of containment, should reduce significantly the consequences of core-melt as well.

The ACRS, in a "Report on TMI-2 Lessons Learned Task Force Final Report" on December 13, 1979, supported the Task Force's recommendation but suggested that each licensee should be required to study systems for mitigation of accidents involving large scale core damage or core melting. The ACRS also recommended that "special attention be given to making a timely decision on possible interim measures for ice condenser. containments."

It was now up to the Commission to decide whether it would confront the issue from a rulemaking standpoint, and if so, how it would do so.

NRC Issues Recommendations

On January 23, 1980, the "TMI Action Plan Steering Group," after studying a range of recommendations, issued a "TMI Action

Plan" (Draft 2, NUREG 0660), in which item 11.B.7 stated that the staff was preparing interim hydrogen control requirements for small containment structures. Furthermore, Item 11.B.8 deemed consideration of a rulemaking proceeding on the subject of degraded cores and hydrogen management as appropriate.

On February 22, 1980, NCR's Office of Nuclear Reactor Regulation issued a memorandum to the commissioners regarding proposed interim hydrogen control requirements for small containments (SECY-80-107) in response to the call for an interim requirement in 11.B.7. The cover letter of SECY-80-107 is reproduced as Exhibit A-3. The staff found that, based on its review of the TMI-2 experience, inerting of all BWR Mark I and Mark II containments would be needed as an interim control requirement. With regard to ice condenser containments, the staff concluded:

> In an ice condenser containment, the maximum amount of metal-water reaction that can occur without exceeding the containment failure pressure is 25 percent. This assumes a failure pressure of 36 psig, combustion of the hydrogen gas and availability of only one of the two trains of containment spray systems for a spray flow of 3400 gallons per minute. A 15 percent metal-water reaction would lead to a peak containment pressure equal to the design pressure of 12 psig... Therefore in view of the feasibility question [of inerting the ice condenser containment] and the fact that about 25 percent metal-water reaction can be tolerated even with burning, we conclude that, pending the rulemaking proceeding, additional mitigation systems are not required for ice condenser containments.

On March 19, 1080, a Commission briefing was held on SECY-80-107, at which the commissioners requested additional information; the staff later provided this information in SECY-80-107A and SECY-70-107B, issued on April 22, 1980 and June 20, 1980, respectively.

As proposals for dealing with the hydrogen control problem for small containment PWR's hinged largely on the mitigation method, much of the technical basis for any interim hydrogen control requirements depended on how much hydrogen would actually be produced and how best to prevent danger from containment failure or hydrogen burn. Appropriately, the NRC began research at Sandia National Laboratories, Albuquerque, New Mexico, to address these issues.

In the fall of 1980, a Sandia team presented the results of their study of literature concerning generation, transport, detection, and combustion of hydrogen which might occur

during serious LWR accidents. (2) The document addressed the threat to containment posed by hydrogen generation in excess of design bases and found that hydrogen recombiners, designed to operate in non flammable mixtures at very low rates, were primarily intended to handle the radiolytic generation of hydrogen. They alone would be inadequate for accidents in which the core had been uncovered and metal-water reactions were occuring in a TMI-type accident.

Meanwhile, a formal announcement of the NRC's proposal to amend its regulations with regard to hydrogen control and degraded core accidents had been issued. The staff indicated that, pending an Interim Rule on Hydrogen Control, the staff would require that a significant fraction (about 75 percent) of the fuel cladding be assumed to undergo metal-water reaction and that the design provide means for dealing with the hydrogen thus generated as follows:

(a) For the BWR Mark I and Mark II containments, an inerted (oxygen-removed) atmosphere is required; and

(b) For all ice condenser and Mark III containments, additional hydrogen control methods are required to ensure safe shutdown and maintain containment integrity.

Impact on the Sequoyah Plant

As interest in the hydrogen control issue grew, the NRC sponsored further research at Sandia to study different hydrogen mitigation schemes. The Commission's sudden interest was not purely academic -- at the time of the accident at TMI-2, there were a total of ten licensed ice condenser units in the U.S. Two of the ten, D.C. Cook, Units 1 and 2, were licensed for operation at full power, and Sequoyah Nuclear Power Plant's Unit 1 was licensed to operate up to 5 percent of full power. The other seven units were under various stages of construction, as was McGuire.

On September 17, 1980, the NRC issued operating license DPR-77 to the Tennessee Valley Authority (TVA) for Sequoyah-1, but requested resolution of the hydrogen issue to the Commission's satisfaction before January 31, 1981. Earlier, TVA engineers had installed an Interim Deliberate Ignition System (IDIS) consisting of several hydrogen igniters -- General

(2) Sherman, M.P., Berman, M., et al, "The Behavior of Hydrogen During Accidents in Light Water Reactors," NUREG/CR-1561, SAND80-1495, Sandia National Laboratories, Albuquerque, NM, August 1980.

Motors AC Division model 7G diesel engine glow plugs -- placed throughout the inside of the containment. As their "Report on the Safety Evaluation of the Interim Distributed Ignition System" detailed, the purpose of the igniters was to deliberately burn off any hydrogen generated such that flammability limits were not reached.

ACRS, in a September 8 letter to NRC Chairman John F. Ahearn, gave preliminary approval to the Sequoyah IDIS. See Exhibit A-4.

Soon afterwards, the NRC staff completed their review of the report, and in Supplement 3 to Sequoyah's SER (NUREG-0011), indicated that the IDIS had a good chance of being established as a worthwhile safety measure, and recommended authorization for operation at 50 percent of full power.

Engineers at Duke Power Company would watch closely the licensing of Sequoyah -- whatever was determined at Sequoyah would have an effect on the licensing of McGuire.

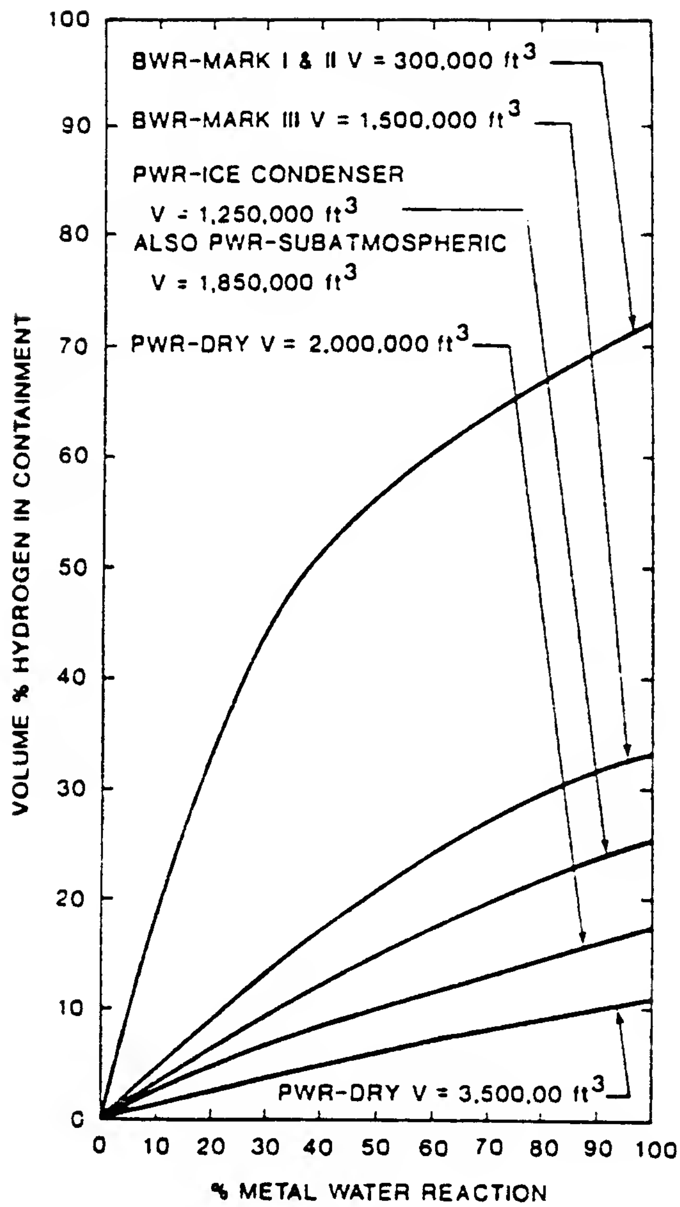


Exhibit A-1

Vol % in Containment vs. % Metal-water Reaction, from Z. M. Shapiro and T. R. Moffette "Hydrogen Flammability Data and Applications to PWR Loss-of-Coolant Accident," WAPD-SC-545, Bettis Plant, Pittsburgh, Pennsylvania, September 1957.

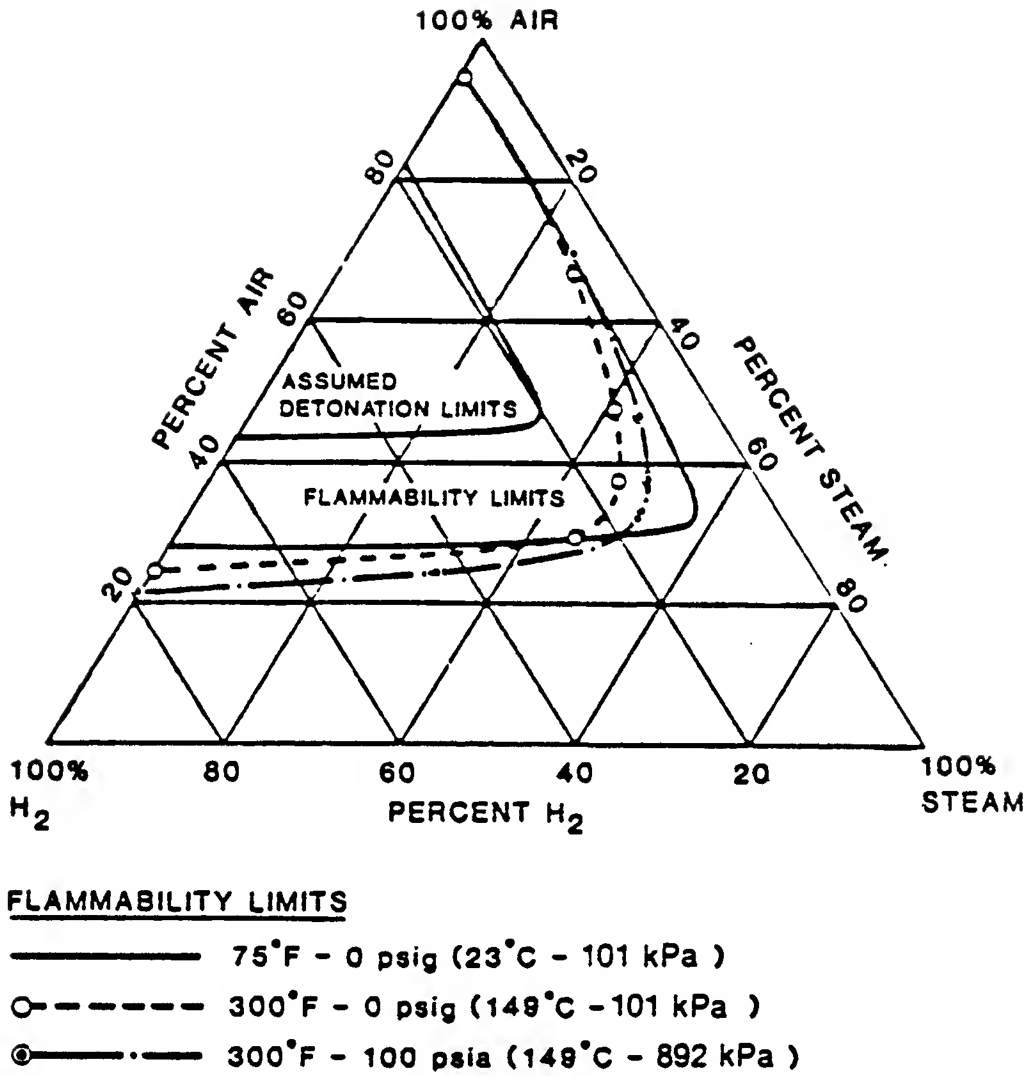


Exhibit A-2

Flammability and Detonation Limits of Hydrogen-air-steam Mixtures, from Z. M. Shapiro and T. R. Moffette "Hydrogen Flammability Data and Applications to PWR Loss-of-Coolant Accident," WAPD-SC-545, Bettis Plant, Pittsburgh, Pennsylvania, September 1957.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

February 22, 1980

POLICY SESSION ITEM

SECY-80-107

MEMORANDUM FOR: The Commissioners

THRU: W. Dircks, Acting Executive Director for Operations

FROM: H. Denton, Director, Office of Nuclear Reactor Regulation

SUBJECT: PROPOSED INTERIM HYDROGEN CONTROL REQUIREMENTS FOR SMALL CONTAINMENTS

Purpose: To establish the technical basis for interim hydrogen control requirements for small containments

Discussion: The accident at Three Mile Island, Unit 2 (TMI-2) involved a large amount of metal-water reaction in the core with resulting hydrogen generation well in excess of the amounts specified in 10 CFR 50.44 of the Commission's regulations. A rulemaking proceeding on the subject of degraded cores and hydrogen management is under consideration by the Commission. This proceeding was suggested in Item 11.8.8 of the "NRC Action Plans Developed as a Result of the TMI-2 Accident," Draft 2, NUREG-0660, January 23, 1980.

Based on our review of the TMI-2 experience, we have found that certain interim hydrogen control requirements for small containments are needed. This interim action would require the inerting of all Mark I and Mark II containments for boiling water reactor plants.

The enclosed technical discussion provides the bases for: 1) the proposed interim action; and 2) continued operation and licensing of nuclear power plants pending the rulemaking proceeding.

The proposed interim rule requiring inerting of the Mark I and Mark II containments, and including other measures to protect against degraded core conditions that need to be implemented in the near term, is in preparation and will be sent to the Commission soon.

Contact: W. R. Butler, NRR (x27783)

Coordination: The Offices of Standards Development and Inspection and Enforcement concur in the proposed action. The Office of the Executive Legal Director has no legal objection.

Sunshine Act: Recommend consideration at an open meeting.

Scheduling: For early consideration.

Roger J Mattson 2/22/80
Harold R. Denton, Director
Office of Nuclear Reactor Regulation

Enclosures:
Technical Discussion

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ECL 260A

Exhibit A-3
SECY-80-107 Cover Letter

September 8, 1980

Honorable John F. Ahearne
Chairman
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Dr. Ahearne:

SUBJECT: SEQUOYAH NUCLEAR POWER PLANT, UNITS 1 AND 2

In connection with the Committee's review of the Sequoyah Nuclear Plant, Commissioner Gilinsky has addressed specific questions to the ACRS regarding ice condenser containments. This is in response to your request for the Committee's comments on the questions raised by Commissioner Gilinsky in his letter of August 7, 1980.

1) "Does the Committee believe additional hydrogen control measures are necessary for ice condenser containments?"

An intensive review of the capability of the Sequoyah containment has recently been completed. Independent estimates have been made by the Applicant, the NRC staff, various consultants, and the ACRS Subcommittee on Structural Engineering. As a result, it has been concluded that the Sequoyah containment is capable of sustaining a pressure of at least 45 psig without structural failure. On this basis, the containment structure could tolerate burning of all the hydrogen evolved from the oxidization of 20%, or so, of the zirconium in the reactor, assuming the hydrogen was uniformly distributed in the containment atmosphere. Hence, there is a range of accidents involving severe core damage for which additional hydrogen control measures are not necessary. Of course, it would also be necessary to ascertain that all the essential equipment in the containment could withstand such an event. TVA has stated that they are conducting a thorough review of this matter.

For a full scale core meltdown there is no assurance that failure of the containment could be avoided merely by the use of hydrogen control measures. For events involving more than about 30% oxidation of the zirconium, hydrogen control measures may be necessary to avoid containment failure.

A similar situation, though not identical in detail, would be expected to apply to ice condenser plants other than Sequoyah.

The Committee believes that it would be prudent to provide additional hydrogen control measures for ice condenser containments, and that studies to demonstrate the effectiveness, reliability, and absence of significant adverse effects of candidate measures should be pursued actively on a time scale that would permit their application before more than a few additional reactor years of operation of ice condenser containment plants have elapsed. As stated in our Sequoyah Report of July 15, 1980, in the Committee's opinion, there is no need to delay the issuance of a full power operating license for Sequoyah until these studies have been completed.

2) "Is the committee reasonably persuaded of the effectiveness of distributed igniters in ice condenser containments? Can such igniters be counted on to keep pressure increases caused by hydrogen burns at suitably low values -- which I would define as design pressures -- during accident sequences involving TMI-like quantities of hydrogen?"

On the basis of the preliminary information available, it appears that a distributed ignition system of the type considered for Sequoyah may provide a good capability of controlling the burning of a large amount of hydrogen. It is yet to be established at just what hydrogen concentration a particular style of igniter will provide ignition with high reliability under the conditions anticipated. With the assumption that it can be shown that this concentration is little, if any, higher than the average when the burn occurred at TMI-2, the pressure levels induced by iterated ignition would be well within the 45 psig capability of the Sequoyah containment. There is no present basis for assurance that the pressure increases can be held below the design pressure -- nor would there seem to be any need to do so under the circumstances considered. The hoped for, and expected, performance would be capable of disposing of all the hydrogen that might present itself, up to the point (about 800 kg burned) at which the oxygen level in the containment atmosphere should drop to about 5%, after which no further hydrogen could burn. This, of course, would depend on the continuing operation of the containment heat removal systems.

The action of the igniters will probably reduce the risk, since there will be at least as many ignition events with them in use as if only unintended ignition sources were present. The average amount of hydrogen per burning event should therefore be smaller, and the chance that a large pocket of ignitable or detonable hydrogen could survive without ignition (while waiting for a random source to act) will be reduced.

The results of the present testing program will, of course, be necessary before concluding that the ignition system being studied meets all the necessary objectives.

Sincerely,

Milton S. Plesset
Chairman

References
1. U. S. Nuclear Regulatory Commission, "Safety Evaluation Report Related to the Operation of Sequoyah Nuclear Plant, Units 1 and 2," USNRC Report NUREG-0011, Supplement No. 2, August 1980.

2. U. S. Nuclear Regulatory Commission, "Safety Evaluation Report Related to the Operation of Sequoyah Nuclear Plant, Units 1 and 2, USNRC Report NUREG-0011, Supplement No. 3, September 1980.

3. Letter from Commissioner V. Gilinsky to M. Plesset, Chairman, Advisory Committee on Reactor Safeguards, dated August 7, 1980.

Exhibit A-4
ACRS Letter to NRC re Hydrogen Problem
(retyped to improve clarity)

PART B: DUKE POWER COMPANY'S RESPONSE TO TMI-2

Bill Rasin, head of the Nuclear Engineering group in the Design Engineering division after five years with Duke Power, had worked at the University of Virginia reactor research facility for six years while obtaining his nuclear engineering degree, and, prior to that, had eight years experience with the Navy's nuclear submarine program. So when the accident at TMI-2 occurred, Duke, still waiting for a decision by the NRC Atomic Safety and Licensing Board (ASLB) on their operating license application, promptly sent Rasin to TMI. Arriving at TMI on April 1, 1979, Rasin worked with a team whose job was to assess the core damage and later, to work on the hydrogen "bubble" concern.

Preliminary Study of McGuire's Hydrogen Problem

Returning to Charlotte, Rasin led his group in reviewing McGuire's plant design to determine the potential for a TMI-type accident at McGuire, looking specifically at the hydrogen control question. After a preliminary assessment, Rasin concluded, "We didn't worry too much about hydrogen because we felt it posed no threat to containment integrity." Rasin based his judgement on the differences between the accident at TMI and what would happen at McGuire.

Continued study on the hydrogen issue at McGuire stagnated also because the Licensing Board, on April 18, 1979, issued Duke an Initial Decision (Operating License Proceeding), LBP-79-13, 9 NRC 489 (1979), which stayed the effectiveness of the ASLB initial favorable decision "until further order by the Board following the issuance of a supplement to the Nuclear Regulatory Commission Staff's Safety Evaluation Report addressing the significance of any unresolved safety issues." Duke now had to wait for the NRC staff to issue another SER supplement before the Licensing Board would continue consideration of the license application.

Furthermore, Duke was following closely the licensing actions at Sequoyah, where a deliberate ignition system was already in place and being reviewed by the Commission. The licensing of the two reactors proceeded in parallel, in the sense that the licensing of McGuire was always about one year behind the licensing of Sequoyah.

The Licensing group in the Steam Production division at Duke Power, meanwhile, was going through the process of compliance with the TMI-2 Lessons Learned Task Force Recommendations when the group noticed NRC emphasis on the hydrogen problem begin to increase. Skip Copp, a nuclear licensing engineer at Duke for several years, and Tom Heitman, a rookie

only a year out of the University of Virginia, anticipated the role the hydrogen issue might play during McGuire's licensing, and started studying the problem. "It became clear we would have to do something," commented Copp.

After Heitman attended a two-day Nuclear Safety Analysis Center (NSAC) workshop on hydrogen burning and containment building integrity (NSAC is operated by the Electric Power Research Institute (EPRI)) in March of 1980, and when it became more and more clear that the hydrogen question would arise in the operating license discussions, Heitman and Rasin formed the core of an in-house team to study the problem in detail and develop a solution.

Opposition From the Environmental Community

In April 1980, word spread that the president of the Carolina Environmental Study Group (CESG), Jesse Riley, was considering re-opening the ASLB hearings in opposition to the operating license. CESG, a vocal nuclear citizen's group, had opposed the design and construction of McGuire from its very beginnings, and was intent on this one last chance to delay, or even better yet, cancel, operation of the reactor.

Riley seized upon the hydrogen issue as soon as he heard that the TMI accident, had it occurred at McGuire, would have had serious consequences. A Charlotte-Mecklenburg Environmental Coalition was formed, and Riley became busy recruiting support for his opposition plan (see Exhibit B-1 for a sample leaflet). There was no way such an obvious danger to the community would be overlooked, thought Riley.

Consequently, Rasin and Heitman's hydrogen team accelerated their efforts; "We were confident that design steps to mitigate hydrogen were unneeded, but we also realized that, with Riley re-opening the hearings, we would need a strong technical case," recalled Rasin.

On May 23, 1980, the NRC staff issued Supplement No. 3 to the McGuire SER, and on May 30, 1980, Duke moved the Licensing Board lift its stay of the initial decision. CESG promptly filed a response opposing Duke's motion to lift the stay and, in addition, filed a motion requesting the re-opening of the McGuire operating license hearing and admission of CESG's contentions. CESG argued that a TMI-type of accident involving hydrogen release and rapid combustion at McGuire could adversely affect public health and safety by causing the rupture of the reactor containment building and release of radioactivity to the atmosphere.

On August 15, 1980, CESG resubmitted a revised set of contentions and amended its motion to re-open the hearings. On November 25, 1980 , the Licensing Board granted CESG's motion to re-open the hearings, admitting CESG's four contentions, and denying Duke's motion to lift the stay of the initial decision. This was the environmental group's chance.

Meanwhile, Duke's hydrogen team had met with and interviewed TVA and other engineering consultants to learn all it could on the subject of hydrogen control and its particular significance for ice condenser plant operators and owners. The engineers quickly learned that "hydrogen is a tricky animal," according to Heitman. The Sequoyah SER Supplement 3, issued in September 1980, put additional pressure on the team to develop some system to mitigate hydrogen.

Charlotte-Mecklenburg Environmental Coalition

Audubon Society
Dick Brown

Carolina Action
Brenda Best

...na Environmental
Study Group
Jesse Riley
... Pressler (Chairman)

...son Energy Group
Dawn Wilson

... of Women Voters
June Kimmel

...e Energy Alliance
Mike Fennell

Sierra Club
Margaret Miller

IS THE MCGUIRE NUCLEAR POWER PLANT SAFE?

The McGuire Nuclear Station, located just 17 miles north of Charlotte, on Lake Norman, is scheduled to go into operation any time now. Could it withstand an accident like the one that happened at Three Mile Island?

According to a Nuclear Regulatory Commission study dated June 26, 1980, SECY 80-107:

1. McGuire's containment is built to withstand 15 pounds of pressure per square inch.
2. The containment at Three Mile Island was built to withstand 65 pounds of pressure per square inch.
3. At the height of the Three Mile Island accident, the pressure within the containment reached 28 pounds per square inch, due to the rapid hydrogen buildup and combustion.

The result was a frightening situation totally unplanned for by the engineers present. At one point, the reactor was just minutes from a meltdown.

Therefore, it is clear that in a Three Mile Island-type accident at McGuire, if there were an equal buildup of hydrogen pressure within the containment, the containment would yield, releasing deadly, radioactive gases into the air we breathe.

Are we willing to take the risk of a nuclear catastrophe, contaminating our air, water and food because of a weak containment? What are the unknown hazards of radiation? Would a major accident cause cancer epidemics 15 to 20 years later? Would any amount of radiation released into the atmosphere be too much?

There is something we can do.

Write a letter to the Nuclear Regulatory Commission, urging them to reopen the McGuire licensing hearings. Express your concern over the operation of McGuire and the specific problem of low containment. The NRC may be persuaded to reopen the hearings, and public opinion will be a crucial factor in such a decision.

In your letter, refer to the study dated June 26, 1980, SECY 80-107, "Proposed Interim Hydrogen Control Requirements for Small Containment." This will insure that the proper authorities get your letter. Simply address your letter to:

United States Nuclear Regulatory Commission
Washington, D. C. 20555

... 24 1980
Office of the Secretary
...
GH

Charlotte-Mecklenburg
Environmental Coalition
704/372-5889

943 Henley Place • Charlotte, North Carolina 28207

Exhibit B-1

Sample Leaflet - Charlotte Mecklenburg Environmental Coalition

PART C: PREPARATIONS FOR THE HEARINGS

Selection of Deliberate Ignition

Bill Rasin, studying the hydrogen problem through industry sponsored research results, moved in favor of the deliberate ignition system -- the method employed at Sequoyah. "It was the way to go given what we knew at the time," he indicated.

Rasin argued against inerting and filtered venting, noting that studies had indicated that inerting was too much of a hazard for operators of ice condenser units, as well as too expensive, whereas filtered venting could not control a pressure spike predicted during a hydrogen burn. Post-accident inerting with halons, further maintained Rasin, presented unanswered questions with respect to the chemical compatibility with other reactor substances. Copp added that because of the short time frame within which Duke was working, the team was limited by practicality and acceptability of any new system. Besides, Rasin pointed out, Duke had not ruled out other mitigation systems, it was just that the deliberate ignition plan, using diesel engine glow plugs, was simple, inexpensive, easy to install, and could do the job adequately.

McGuire Project Manager Birkel called the deliberate ignition system the one that "seems to be the best of all evils," referring to the complications posed by other mitigation methods. He indicated that the utility went ahead with the installation "somewhat voluntarily," for a November 14, 1980 letter (Exhibit C-1) from the NRC specified requirements for providing an appropriate hydrogen control system. The requirements were similar to those requested of TVA for the continuation of the Sequoyah licensing process. Duke got the message and a deliberate ignition system for McGuire was designed and installed, even though Rasin still strongly felt it was unnecessary given the upgrading of equipment reliability and operator training at McGuire as a result of the TMI-2 accident. Since, however, it was needed to convince the NRC that McGuire could be licensed, as evidenced by the Commission's interim approval of Sequoyah's IDIS on January 29, 1981, the team decided to complete installation of the system while continuing study to ensure its adequacy in uncontrolled hydrogen burn mitigation.

Request for Partial Power License

On the licensing scene, Heitman, realizing the difficulty of obtaining a full power license under hearing conditions, decided to recommend that Duke apply for a low power license, just to get through the hearings. For fuel loading, initial criticality, zero power physics testing, and low power testing, Duke engineers felt that the hydrogen issue posed no threat from 5 percent power operation. "We knew that, at the time,

Riley had not been formally admitted with the new contentions, but we felt it likely that he would be," said Heitman, "so since we didn't want to be delayed more than necessary, we decided to ask for a low power license. It was a tactical decision."

Unfortunately for Duke, the Licensing Board's November 25, 1980, decision to grant CESG's motion to re-open the hearings was accompanied by a decision denying Duke's request for fuel loading, initial criticality, and zero power physics testing. It was not convinced that generation of hydrogen in excess of design basis regulations was precluded at low power operation. This decision was affirmed by the ASLAB on January 6, 1981, and on January 23, 1981, the NRC issued NPF-9 for Unit 1 -- the fifth nuclear unit to reach the stage of fuel loading since TMI-2 two years ago.

Hearing Date Approaches

As the hearing date drew nearer, the Duke team anxiously prepared its arguments while continuing licensing activities. The NRC staff held a meeting on February 2, 1981, with Duke engineers to discuss the effect of hydrogen burns on vital equipment in the containment, and research results from Sandia and other research laboratories began to surface. A February 17, 1981, letter (Exhibit C-2)enclosed with a detailed report of the new hydrogen mitigation system contended that "hydrogen will not be generated in excess of the limits set forth in 10 CFR 50.44 and no additional safety systems are necessary " Warren Owen, senior vice president, engineering and construction, of Duke Power, also rebutted claims of the likelihood of dangerous hydrogen explosions at McGuire in The Charlotte Observer on February 19, 1982 (Exhibit C-3).

Duke felt confident of its case.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON D C 20555

Docket Nos.: 50-369/370

11/14/80

Duke Power Company
ATTN: Mr. William O. Parker, Jr.
Vice President - Steam Production
P. O. Box 33189
422 South Church Street
Charlotte, North Carolina 28242

Dear Mr. Parker:

Subject: Hydrogen Control Measures
(McGuire Nuclear Station, Units 1 and 2)

In your letter to H. R. Denton, dated August 27, 1980, you describe the short and long term activities of the Duke Power Company task force regarding the hydrogen control issue for the William B. McGuire Nuclear Station, Units 1 and 2. Previously on August 22, 1980, we provided you with copies of recent material concerning our review of the ice condenser containment and hydrogen control measures for the Sequoyah Nuclear Power Plant. We note that your present position is to defer any decision to install a system for hydrogen control under degraded core accident conditions pending the outcome of the degraded core rulemaking proceeding. Statements appearing in our SECY-80-107 series of Commission papers and in the report of the Advisory Committee on Reactor Safeguards (ACRS) to the Commission dated July 15, 1980, in the matter of the Tennessee Valley Authority (TVA) application for authorization to operate the Sequoyah Nuclear Plant, Units 1 and 2, at full power, are referenced in support of your approach.

Recent developments in the matter of TVA's application for the Sequoyah plants have indicated that your plans to defer implementation of the appropriate additional hydrogen control measures for the McGuire plants to the rulemaking proceeding are unacceptable. In responding to certain questions regarding additional hydrogen control measures for ice condenser containments, the ACRS stated to the Commission on September 5, 1980 that "...it would be prudent to provide additional hydrogen control measures for ice condenser containments, and that studies to demonstrate the effectiveness, reliability and absence of significant adverse effects of candidate measures should be pursued actively on a time scale that would permit their application before more than a few additional reactor years of operation of ice condenser containments plants have elapsed." It is our position that ice condenser plants be equipped with an operational hydrogen control system beyond those called for in 10 CFR Section 50.44 in a time-frame corresponding to your schedule for starting full power operation at the McGuire Station, Unit 1. This position was stated during the Commission meeting of September 16, 1980 and subsequently, the following conditions for the Sequoyah operating license were approved:

Mr. William O. Parker - 2 -

"D. Hydrogen Control Measures

(a) By January 31, 1981, TVA shall by testing and analysis show to the satisfaction of the NRC staff that an interim hydrogen control system will provide with reasonable assurance protection against breach of containment in the event that a substantial quantity of hydrogen is generated.

(b) For operation of the facility beyond January 31, 1982, the Commission must confirm that an adequate hydrogen control system for the plant is installed and will perform its intended function in a manner that provides adequate safety margins.

(c) During the interim period of operation, TVA shall continue a research program on hydrogen control measures and the effects of hydrogen burns on safety functions and shall submit to the NRC quarterly reports on that research program."

We, therefore, require that you submit: (1) plans for installing an appropriate hydrogen control system for degraded core accident situations, (2) an installation schedule and (3) a detailed description of your program for studies and tests needed to demonstrate the effectiveness and reliability of the proposed additional hydrogen control system. The scheduling of these efforts should be compatible with the licensing activities leading to the issuance of a full power operating license for the McGuire plants. In this regard, you may wish to consider the course of action taken by TVA for the Sequoyah plants.

There is also the matter of the ongoing analysis of the maximum internal pressure capability of the McGuire containment. We also request you submit your analysis and conclusions in the near term to permit the staff review to proceed on this matter in a timely manner.

In order that we may proceed to complete our review of your application to meet your projected fuel load date, we require that the requested information be provided no later than November 24, 1980.

Sincerely,

Darrell G. Eisenhut, Director
Division of Licensing
Office of Nuclear Reactor Regulation

cc: See next page

8019010536

Exhibit C-1
NRC Letter to Duke Power Company Re Hydrogen Control at Mcguire

DUKE POWER COMPANY
POWER BUILDING
422 SOUTH CHURCH STREET, CHARLOTTE, N. C. 28242

WILLIAM O. PARKER, JR.
VICE PRESIDENT
STEAM PRODUCTION

TELEPHONE: AREA 704
373-4083

February 17, 1981

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. B. J. Youngblood
Licensing Projects Branch No. 1

Re: McGuire Nuclear Station
Docket Nos. 50-369 and 50-370

Dear Mr. Denton:

The accident which occurred at TMI Unit 2 resulted in the generation of hydrogen beyond the limits specified in 10CFR §50.44. This excessive hydrogen generation was primarily due to premature termination of the emergency core cooling system (ECCS). Duke Power Company believes that measures taken subsequent to the accident at TMI Unit 2 effectively preclude premature termination of the ECCS in the event of an accident requiring its initiation. Therefore, hydrogen will not be generated in amounts in excess of the limits set forth in 10CFR §50.44 and no additional safety systems are necessary.

However, Duke has installed a system for controlling the effects of excessive hydrogen generation in the extremely unlikely event of an accident resulting in such hydrogen generation at McGuire Nuclear Station. This system is described in the document "Duke Power Company, An Analysis of Hydrogen Control Measures at McGuire Nuclear Station." Volumes 1 and 2 of this document were submitted to the NRC on November 17, 1980. Volume 3 was submitted to the NRC on January 5, 1981. Fifteen copies of Volume 4 are enclosed with this letter. Also enclosed are fifteen copies of errata for Volume 2. This document is summarized below.

Chapter 1 provides an introduction to the control of hydrogen generation at light water cooled nuclear power plants.

Chapter 2 presents analyses which have been performed to study hydrogen burn transients in ice condenser containments for an accident sequence similar to the TMI-2 accident. At TMI-2 equipment failure coupled with dynamic man-machine interactions led to an arrested core melt event.

Accident sequences proceeding beyond the stage of an arrested core melt include events beyond the question of hydrogen generation and as such are not appropriate for evaluating the effectiveness of a hydrogen control system. Therefore, in order to evaluate the effectiveness of a hydrogen control system it is reasonable to select an accident sequence that is comparable to the TMI-2 accident. As such, the small break LOCA with failure of safety injection (the S_2D sequence in WASH 1400) was selected for this evaluation. The selection of a small break LOCA is even more appropriate considering the conclusion of WASH 1400 that "(these) sequences contribute the largest probability to PWR core melt." The S_2D sequence is representative of TMI-type sequences in which a hydrogen control system may be called upon to function.

Chapter 3 provides a description of the Emergency Hydrogen Mitigation (EHM) system which has been installed at McGuire Nuclear Station Unit 1. The operation and testing of this system is described in Chapter 8. A test program which demonstrates the effectiveness of the EHM system igniters is described in Chapter 5.

Chapter 4 describes a detailed structural analysis of the McGuire containment which established the functional capability of the McGuire containment as 67.5 psig. The structural response of the McGuire containment to a postulated localized hydrogen detonation is discussed in Chapter 7. This evaluation was conducted even though investigations show detonable mixtures of hydrogen will not be formed as the result of a postulated TMI-type accident at McGuire. The analyses discussed in Chapters 4 and 7 provide assurance that the McGuire containment can withstand the effects of a TMI-type accident.

Chapter 6 discusses the effects of hydrogen combustion on equipment located inside containment.

Very truly yours,

William O. Parker, Jr.

William O. Parker, Jr.

THH:aca

Enclosures - See category A for Volumes 1, 2, 3

8102200394

Exhibit C-2

Duke Power Company Letter to NRC Re Hydrogen Control at McGuire

What About McGuire?

Because of major design and procedural differences, the possibility of a similar hydrogen explosion inside the containment is virtually precluded at McGuire.

Two letters in The Observer Forum Feb. 12 cited the danger of a hydrogen gas explosion at the McGuire nuclear plant near Charlotte. The Observer asked Duke Power Co. to respond to those letters. The writer is senior vice president, engineering and construction, for Duke Power.

Public hearings on the McGuire plant begin at 9:30 a.m. Feb. 24 at the Charlotte-Mecklenburg public library, 310 N. Tryon Street.

Safety is the major factor in the design and construction of the McGuire Nuclear Station and will continue to be the foremost objective once the facility is operational.

Duke Power does not make this pledge lightly. Our company has been designing and building its own electric generating plants for 77 years, rather than having outside firms do the work for us. This is how we've achieved an operating record second to no other electric utility in the nation.

Owen

For example, in 1978, Duke Power's fossil-fueled generating system was rated the most efficient in the nation for the fifth straight year. The company earned six of the top ten spots for individual generating unit performance. Among the nation's nuclear units, Oconee Unit 3 operated at the highest efficiency in 1978, according to the Nuclear Regulatory Commission (NRC). Oconee Unit 1 ranked fourth.

Since 1955, many Duke employees have been involved full-time in nuclear projects. So respected is their expertise that several engineers were summoned to Pennsylvania when the Three Mile Island accident occurred.

A major concern since then has been the possibility of a similar hydrogen explosion in the containment of a nuclear power plant. Because of major design and procedural differences, this possibility is virtually precluded at McGuire.

First, let's look at the human side. Since Three Mile Island, we've made it easier for the operators to make sure the fuel core always is covered with water, and we've changed control room instrumentation to clarify the information we get from the core and its containment. Furthermore, we've added a shift technical adviser whose major responsibility is to monitor the core at all times. Well-trained and knowledgeable operators, then, are our major assets in avoiding an accident.

Nonetheless, if an accident would occur that caused hydrogen production, systems already existing in the McGuire containment (such as the ice condenser, the air-return fans, and the containment spray system) would act to lessen the severity of a hydrogen burn. Additionally, the recently installed hydrogen igniters would act to burn hydrogen, preventing any dangerous build-up from occurring.

Both the design pressure (15 pounds per square inch) and the actual pressure that could be withstood in the McGuire containment are conservatively estimated. The 15 pounds per square inch, for instance, is calculated on the basis of the containment experiencing simultaneously both a loss of coolant accident and an earthquake. Two recent studies, however, indicated that the McGuire containment could actually withstand an internal pressure of 67½ pounds per square inch.

The Sequoyah Nuclear Plant in Tennessee was recently granted an operating permit by the Nuclear Regulatory Commission. The Sequoyah containment, nearly identical to McGuire but with a design pressure of 10.8 pounds per square inch, can withstand an internal pressure of 45 pounds per square inch.

McGuire Nuclear Station, in a matter of weeks, will be ready to produce electricity. A hearing before the Atomic Safety and Licensing Board is scheduled to commence Feb. 24 in Charlotte and is expected to continue for two to three weeks. Although this hearing will concern itself with a reinvestigation of hydrogen generation, this issue was resolved by the NRC prior to the issuance of the Sequoyah license. Duke is confident that the NRC will determine again that the public health and safety are more than adequately protected.

WARREN H. OWEN

Charlotte

Exhibit C-3
Article in <u>The Charlotte Observer</u>
February 19, 1981

PART D: THE LICENSING HEARINGS

Tension was high as attorney Michael McGarry steeled himself for the first day of the ASLB re-opened hearings on February 24, 1981. Having previously represented Duke Power for several years on various nuclear power issues, McGarry had spent the last few months preparing for the hearings. Reflecting now, as he would again later, he marveled at the tremendous interaction he had had and would continue to have with the Duke engineers. They were a team -- not just the engineers doing the engineering and the lawyers doing the lawyering -- the last few weeks had been a period of intense effort and collaboration.

Now, as McGarry sat before the three administrative judges at the spectator-filled Wagoner Hall in the Holiday Inn North, Charlotte: Robert M. Lazo, chairman, Emmeth Luebke, and Richard Cole, he reviewed both sides of the case.

The Main Issues

The first two CESG contentions were:

Contention 1: The licensee has not demonstrated that, in the event of a loss-of-coolant accident at McGuire:

1. substantial quantities of hydrogen (in excess of the design basis of 10 CFR 50.44) will not be generated; and

2. that, in the event of such a generation, the hydrogen will not combust; and

3. that, in the event of such a generation and combustion, the containment has the ability to withstand pressure below or above the containment design pressure, thereby preventing releases of off-site radiation in excess of Part 100 guideline values.

Contention 2: Neither licensee nor NRC staff has demonstrated that a McGuire ice containment will not breach as the result of the rapid combustion of quantities of hydrogen which a dry containment would withstand.

Contentions 3 and 4 related to emergency planning and would not be an issue unless the first two contentions were successfully verified.

Duke's basic argument was that McGuire's new equipment design and operator training procedures, as well as other improvements incorporated as a result of TMI-2, effectively discounted any possibility of early operator termination of the ECCS, as at TMI-2; furthermore, even if, by chance, ECCS were in fact terminated, Duke maintained that there was over two hours to re-initiate ECCS before generating an amount of hydrogen in excess of that produced by a 2 percent zirconium-water reaction; and finally, as an independent barrier to release of radioactivity should any hydrogen at all detonate, McGuire's containment structure had been analyzed as being capable of withstanding 67.5 psig -- greater than the 28 psig at TMI-2 and over four times an estimated 16 psig which would occur at McGuire.

The Engineers Testify

After the morning session of limited appearances by some local citizens on their views of the operation of McGuire (there were opinions both for and against the license), McGarry began his case by arranging a panel of Duke Power engineers to testify on measures taken at McGuire in the areas of personnel, equipment, procedures, and training. CESG moved to subpoena several witnesses Riley claimed would refute Duke's testimony, but McGarry argued that they should have applied earlier in conformance with standard procedures. Lazo indicated, however, the matter would be considered at the end of the week.

During the week, Duke engineers and their consultants continued to testify to the CESG charge that hydrogen would cause a TMI-type accident at McGuire. In an analysis of the hydrogen mitigation system, Duke engineers assumed a small break at some point in the primary cooling system (1/2 to 2 inch diameter break), coupled with a failure of the ECCS at the inception (an accident sequence referred to in the 1974 AEC <u>Reactor Safety Study</u>, WASH-1400, as an S2D sequence). The engineers also assumed that the accident progressed long enough to generate a quantity of hydrogen from approximately a 75% zirconium-steam reaction. The peak containment pressure from that hypothetical accident was computed to be less than 16 psig.

Rasin, testifying on the 62 hydrogen igniters installed by Duke in the fall, later commented that his impression was that CESG was not really interested in resolving the actual technical issue, but rather was attacking from all angles in an attempt to discredit Duke's arguments by confusing the issue. "A hearing is a completely different atmosphere from engineering work," he added, "engineers are not trained to prove a case conclusively before three administrative judges."

Also during the first week, CESG and then the Licensing Board and the NRC staff in turn, cross examined the panel and raised many questions concerning hydrogen flow, ice condenser effects, and steam effects on hydrogen burn. The hydrogen team, working with McGarry, would definitely have its hands full during the weekend.

The Second Week of Hearings

On the first day of the second week of the re-opened hearings, the ASLB decided to grant subpoenas to five university psychologists to present testimony on operator stress under accident conditions. A subpoena was also granted to CESG for a former Duke employee, Joe Lanford, who claimed to have information regarding a defective weld at McGuire. CESG's remaining witnesses were not granted subpoenas, but the decision was nonetheless a point for the intervenor.

Riley pointed out that the psychologists were asked to testify against the idea that nuclear reactor operators could function predictably under crises situations. During the week, the psychologists discussed the effects of stress, amnesia, job boredom, and mental fatigue, although they did not relate the general phenomena discussed to nuclear power plant operations or control room activities.

For McGarry, the highlight of the second week of testimony was the Licensing Board's decision, at the urging of McGarry, that Riley's testimony be struck from the record. As president of the intervening group, and a key witness, Riley was a retired research chemist for Celanese Corp. McGarry argued that only experts are allowed to give opinions in matters before the Board, and since Riley was not considered by the Board to be an expert, Riley was not qualified to testify on the specifics of containment system strength and hydrogen burning and detonation. The Board agreed with McGarry.

Riley was understandably dejected with the Board's decision, and he criticized the Board for being "very sensitive" to what he saw as Duke's desire to license the plant as soon as possible, as reported in the March 6 Charlotte Observer. Duke had "a lot riding on it," Riley said, noting that Duke attorneys had indicated the plant would lose $200,000 each day the plant is not operating, according to The Charlotte News.

Conflicting Technical Opinions

The third week of the hearings presented a new question for the hydrogen team. The author of a report referred to earlier in the hearings, Marshall Berman, supervisor of the Reactor Studies Division at Sandia National Laboratory, was called in by the NRC staff panel to discuss a contrasting view of the Duke hydrogen mitigation system.

"We were kept off balance," remembered Heitman, because Berman's testimony conflicted with what Rasin and other Duke panelists had said. In essence, Berman questioned the value of the upper plenum igniters in the event fogging in the lower

compartment prevented igniters there from burning off accumulated hydrogen. In such a scenario, higher concentrations of hydrogen could rise to the upper plenum and, ignited by the upper plenum igniters, possibly cause containment fire. Berman advised further research on the subject.

Rasin disagreed strongly with this idea, arguing that the upper plenum igniters were instrumental in burning the hydrogen at small pressure rises, thereby preventing the potentially dangerous large pressure increase.

The technical disagreement arose because of differences in assumptions and differences in experimental geometry used by Berman. Rasin commented that he felt there was a legitimate technical issue which could have been resolved away from the Licensing Board hearing setting, but under the circumstances, he admitted, there was nothing to do but diagreee.

After Berman was cross examined by the NRC staff, NRC containment systems engineer Charles Tinkler said in summary that, "We feel it's premature to accept the hypothesis that fogging...will cause inerting in the lower compartments of an ice condenser plant." Walter Butler, containment systems branch chief, recommended leaving the igniters where they were pending completion of new studies and further ignition tests by Duke and other utilities.

Wrapping Up the Hearings

The final week of testimony centered on cross examination of the five psychologists, discussion of equipment survivability, and resolution of the Joe Lanford issue. Apparently, Lanford claimed he observed a faulty weld performed while he was working at McGuire, which CESG claimed could lead to early failure of the containment structure. Duke, however, attested to the quality control measures for weld inspections, and F. Lowell Greimann, a project engineer at Ames Laboratory in Iowa, testified that the flaw would be insignificant -- the grade of steel could tolerate small imperfections.

All four weeks of the hearings had been long, tiring, and intense, recalled Heitman, who resorted to sleeping on the couch in McGarry's hotel room many nights when late-night strategy sessions kept the team working late. After 36 expert witnesses and hundreds of pages of technical documentation, Duke continued to press ahead.

At the end of the fourth week, McGarry first moved the Board dismiss the case, since the intervenor had not shown a credible accident sequence at McGuire. Alternately, McGarry proposed, the Board should expedite the decision process and authorize McGuire for a 35 percent power operating license, since Duke

had shown that low power operation would not result in the possibility of any hydrogen generation.

While the Licensing Board would not dismiss the intervenors, it agreed to set dates for required submission of each parties' findings, and, in addition, noted that the 35 percent power application should be properly submitted before the Board would take any action.

On March 24, 1981, Duke formally filed for a 35 percent power operating license, which CESG naturally moved to oppose. The NRC staff studied the application and the hearing testimony to conclude that the low power license could be issued, with the Licensing Board however, having the final say. It was still good news to the Duke Power officials who were getting somewhat impatient.

And so everyone waited.

PART E: THE LICENSING BOARD'S DECISION

Lazo, Luebke, and Cole handed down their decision on May 26, 1981 in a Supplemental Initial Decision (Re-opened Operating License Proceeding), LBP-81-13, 13 NRC 652. The 33 page document analyzed testimony and evidence presented by Duke Power, CESG, and the NRC staff. The Board lifted the stay of the initial decision and authorized the NRR director to issue an operating license for McGuire.

Legal Analysis

In its decision, the Licensing Board first discussed the nature of the CESG contentions and concluded that the contentions should be admitted because "the question of whether there is a credible loss-of-coolant accident involving hydrogen generation, hydrogen combustion and breach or leakage of the containment, with offsite doses in excess of Part 100 guidelines is litigible under 10 CFR 100, notwithstanding the provisions of 10 CFR 50.44."

In other words, the Board decided that an intervenor must show a credible scenario wherein the core is inadequately cooled for a sufficient period of time such that offsite doses in excess of 10 CFR 100 are possible. Part 100 is a siting regulation and establishes radiation limits at a certain boundary from the plant (these radiation exposure limits are 25 rem to the whole body or 300 rem to the thyroid from iodine exposure). The fact that Duke had designed McGuire within 10 CFR 50.44 requirements was not sufficient defense.

The Board based this distinction in part on the 10 CFR 100 requirement of consideration of only "credible" accidents, and in part on a previous Commission memorandum and order (CLI-80-16, May 16, 1980) concerning the TMI-1 restart. In this order, the Commission narrowly admitted the contention of hydrogen control into the restart hearings principally because the TMI-2 accident demonstrated that actual ECCS misoperation resulted in hydrogen generation greater than that postulated in 10 CFR 50.44.

After discussion of matters in controversy and findings of fact, the Board concluded:

(a) There was reasonable assurance that in the event of a TMI-type accident at McGuire, substantial quantities of hydrogen (in excess of the design basis of 10 CFR 50.44) would not be generated; and

(b) The actions taken and procedures adopted by Duke Power Company subsequent to the TMI accident provided reasonable assurance that (i) in the event of a TMI-type accident at McGuire, the likelihood of ECCS operations being prematurely terminated by

> the control room operating staff was so remote that such an accident scenario was not credible; (ii) in the unlikely event of premature termination of the ECCS, operations would be reinitiated within sufficient time to prevent the generation of hydrogen in excess of 10 CFR 50.44; and (iii) the McGuire facility could be operated without undue risk to the public health and safety...

Two subsequent conclusions dealt with the dismissal of the 10 CFR 100 guideline issue because breach of containment had not been established, and consideration of the NRC Supplement 3 to the McGuire SER which was required in the Board's April 18, 1979 Initial Decision.

On the strength of these findings, the Licensing Board then recommended the Commission review the decision and authorize NRR to issue the license.

Encouraged by the favorable ASLB decision, Duke sent a letter to the NRR staff two days later indicating their plan to establish initial criticality by June 19 and to complete zero power physics testing by June 29, and that, as such, would appreciate an expedited final review.

The Continuing Hydrogen Dilemma

In the meantime, research and controversy continued regarding the hydrogen igniters. In March 1981, Berman and his group published an "Analysis of Hydrogen Mitigation for Degraded Core Accidents in the Sequoyah Nuclear Power Plant," NUREG/CR-1762, SAND80-2714, which assessed the effectiveness and practicality of three hydrogen control measures for Sequoyah: deliberate ignition, water fogging, and Halon addition after accident initiation. In the report, Berman continued to stress that the igniters near the upper plenum be removed.

On June 2, 1981, Walter Butler, Chief of the Containment Systems Branch, Division of Systems Integration, NRC, wrote a memorandum to his supervisor, Lester Rubenstein, Assistant director for Core Containment Systems. The memorandum discussed a meeting with John Lee of McGill University in Montreal, who had performed the controversial detonation studies.

Butler first pointed out that significant differences existed between Lee's test conditions and the likely post-accident conditions inside the ice condenser containment. He also wrote that if the lower compartment inerted, there was the possibility that richer mixtures could exist in the ice bed or upper plenum region (even though the staff maintained that the likelihood of the lower compartment inerting was remote). In order, however, for a rich mixture to reach the upper plenum igniters, one must assume the mixture is formed instantaneously or that flame initiated by the igniters would

not propagate downward in the ice bed. Butler noted that Duke consultants maintained that both situations were physically impossible.

Butler concluded that removal of the upper plenum igniters was not justified based on his judgement that the removal of upper plenum igniters could potentially cause random igniting and that the geometries of the test vessel were not representative of the geometries of the ice condenser containment. While the igniter system was useful only in burning hydrogen in small quantities, however, and while "the interim hydrogen control system is perfectly adequate,... we believe that the permanent resolution of the hydrogen control issue requires the demonstration of adequate safety margins." The staff would continue to study the matter.

On June 12, 1981, news arrived that the Commissioners had unanimously approved a 5 percent power operating license for McGuire but denied the request for operation at 35 percent of full power. "We were not surprised," said Copp of the decision against 35 percent power, "even though we felt we had a good technical argument."

While Duke was still waiting on Commissioner review of the Licensing Board decision regarding full power, the NRC staff called Rasin and other Duke engineers to a meeting to discuss initiation of the igniter system at McGuire. There were some disagreements on whether the igniters should be tied to the ECCS, and on the pressure setpoint for startup of the air return fans.

Rasin favored setting the igniters to operate when containment pressure reached 3 psi, and not be triggered every time the reactor's safety injection system was actuated. Also, Duke decided to set the air return fans and sprays to initiate at a higher point than the 3 psi for the igniters themselves. Rasin maintained that the igniters, fans, and sprays would all be in operation before hydrogen would be produced during a transient, and noted that to change the set points for the onset of fans and sprays was not a "painless or inexpensive change to make."

The NRC staff indicated it would study the problems further, but warned Duke of further licensing delays if the licenses were to be conditional on certain aspects of the hydrogen control system.

PART F: THE COMMISSIONERS' DECISION

In a decision very much similar to the one for the operating license for Sequoyah, the Commissioners approved, on June 29, 1981, a full power operating license for McGuire-1. The license was approved after Duke Power agreed to use an igniter hydrogen mitigation system and to license conditions which provide that for operation beyond January 31, 1982, the commission "must confirm that an adequate hydrogen control system for the plant is installed and will perform its intended function in a manner which provides adequate safety margins."

The decision, CLI-81-15, 14 NRC 1 (1981), without the separate comments of several commissioners, appears as Exhibit F-1. As specified in the decision, Duke Power also agreed to continue research on hydrogen control measures and the effect of hydrogen control on safety functions. Further, the order went against Duke Power's preference for ignition only when containment pressure reached 3 psi, requiring Duke to follow Sequoyah's example in which operation of the deliberate ignition system is initiated upon a safety injection signal.

Even more interesting, however, were the separate views of Commissioners Gilinsky and Bradford, who, calling the ASLB ruling "a seriously defective decision," strongly disagreed with the Licensing Board's rationale for their ruling. While Gilinsky and Bradford consented to approve McGuire-1's license because of the conditions of the license, they objected to the approach used by the ASLB in ruling that the chances of a TMI-type accident were "so remote" as to be "not credible." The issue of immediate concern, wrote the commissioners, "is the adequacy of reactor protection against burns or explosions of hydrogen gas which may be generated during an accident."

> "It is a finding that could have been made by a group schooled in the arcane subtleties of nuclear regulation. No ordinary person is capable of such foolishness. After the TMI experience, this review of the credibility of an accident involving hydrogen has been a waste of the parties', the Board's and the Commission's time. It can only contribute to public cynicism about nuclear regulation and the role of public hearings in the decision-making process."

Gilinsky and Bradford wrote.

The two commissioners urged the NRC to "overturn the TMI-precedent, suspend 10 CFR 50.44, and put in place a new rule on hydrogen protection." The Commission should also, they said, adopt an interim rule requiring hydrogen control systems in ice condenser and Mark III containments.

Commissioner Ahearne noted in his comments that the judgemental comments of Gilinsky and Bradford were inappropriate because neither the Commission nor the ASLAB had reviewed the case. Then NRC Chairman Hendrie, in his comments, disagreed with Gilinsky's and Bradford's complaints, saying they were addressing the Commission's standing directions in the matter, and not the Board's actions and decisions.

Cite as 14 NRC 1 (1981) **CLI-81-15**

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

COMMISSIONERS:

Joseph M. Hendrie, Chairman
Victor Gilinsky
Peter A. Bradford
John F. Ahearne

In the Matter of **Docket Nos. 50-369**
50-370

DUKE POWER COMPANY
(William B. McGuire
Nuclear Station, Units 1 and 2) **June 29, 1981**

Following the issuance of a Licensing Board's decision (LBP-81-13) authorizing the Director of Nuclear Reactor Regulation to issue a full-power, full-term license for the operation of Units 1 and 2 of the McGuire facility, and upon the completion of its "effectiveness review" of that decision as it relates to full power operation of Unit 1, the Commission authorizes the Director to issue the full-power, full-term license for the operation of Unit 1. The Commission takes this action without prejudice to its "effectiveness review" for Unit 2, the normal appellate review of the Licensing Board's decision (as it pertains to both Units 1 and 2) by the Appeal Board and by the Commission, and the motion to stay the effectiveness of the Licensing Board's decision now before the Appeal Board.

ORDER

In its supplemental initial decision dated May 26, 1981, the Atomic Safety and Licensing Board resolved the remaining issues in this proceeding and authorized the Director of Nuclear Reactor Regulation, after making the requisite findings, to issue full term licenses to Duke Power Company authorizing full power operation of McGuire Nuclear Station, Units 1 and 2.

Exhibit F-1

NRC Commissioner's Decision

Intervenor, Carolina Environmental Study Group (CESG), has requested the Atomic Safety and Licensing Appeal Board pursuant to 10 C.F.R. 2.788 to stay the effectiveness of the decision. However, quite apart from this stay request, the Licensing Board's initial decision does not become an effective authorization until the Commission has taken the actions outlined in its Order, dated May 28, 1981. These actions entail analysis of the Licensing Board's decision to determine whether it should become effective.

The Commission completed a partial effectiveness review and on June 11, 1981, authorized the Office of Nuclear Reactor Regulation to issue a license to Duke Power Company to operate McGuire Nuclear Station, Unit 1 at steady state reactor core power levels not in excess of 5% of rated power. The Commission has now completed its effectiveness review as it relates to full power operations of Unit 1 and has decided that the Licensing Board's May 26, 1981 supplemental initial decision may become effective insofar as full power operation of Unit 1 is concerned. This effectiveness decision is without prejudice to Commission effectiveness review for Unit 2, the normal appellate review of the Licensing Board's decision by the Appeal Board and by the Commission, and the Intervenor's stay motion filed June 8, 1981, which is now before the Appeal Board.[1]

The likelihood of an accident that would lead to generation of hydrogen in excess of the design limits in 10 C.F.R. 50.44, and the effectiveness of measures to mitigate the consequences of such hydrogen generation, were critical issues in the Commission's deliberations on effectiveness. The licensee has agreed to install and use an igniter hydrogen mitigation system, and has agreed to license conditions which provide that (1) for operation beyond January 31, 1982 the Commission must confirm that an adequate hydrogen control system for the plant is installed and will perform its intended function in a manner that provides adequate safety margins, and (2) during the interim the licensee shall continue a research program on hydrogen control measures and the effects of hydrogen burns on safety functions. The Commission believes that in this case installation and use of an appropriate hydrogen mitigation system is required for adequate protection of the public health and safety.

The Commission believes, however, that operation of the igniter system should be initiated upon a safety injection signal, with accompanying indications of a loss of coolant accident.

[1]On May 15, 1981, Intervenor, CESG, filed a motion with the Commission asking the Commission to order review by an Atomic Safety and Licensing Appeal Board of a portion of the Licensing Board's Memorandum and Order issued in the above-captioned proceeding dated May 6, 1981. CESG's motion is an impermissible effort to obtain interlocutory Commission review of a Licensing Board order and is, therefore, denied. 10 C.F.R. 2.785 and 2.786.

Accordingly, the Director, Office of Nuclear Reactor Regulation is authorized to issue a full power, full term license to Duke Power Company which shall conform substantially to the terms of the June 9, 1981 draft license.

It is so ORDERED.

For the Commission

SAMUEL J. CHILK
Secretary of the Commission

Chairman Hendrie's Additional Views, the Separate Views of Commissioners Gilinsky and Bradford, the Separate Opinion of Commissioner Bradford, and Commissioner Ahearne's Additional Views are attached.

Dated at Washington, D.C.
the 29th day of June, 1981.

PART G: EPILOGUE

"From a regulatory standpoint, one must look at an issue inside and out, again and again, and finally make some sort of conclusion," remarked Birkel, Project Manager for McGuire, referring to the difficult job of a regulator in approving a license -- effectively saying that the plant is safe enough for the public. "There is always some level of uncertainty to an issue," added colleague Stahl, "the Commission would not have licensed Sequoyah and McGuire without safety systems designed to provide some degree of certainty."

To Rasin, Heitman, McGarry and others on Duke Power's "hydrogen team," one thing was certain: after the July 2, 1981, favorable ASLAB decision, the NRR issued the McGuire-1 operating license on July 8, 1981. That meant the celebration of "the end of a two-and-a-half year perpetual short-term project," in Heitman's words. "The whole deal was frustrating, because it was so intense at some times yet so drawn out in others," he noted.

A final rule for inerting Mark I and Mark II BWR's was issued in December 1981. The text of this rule is reproduced as Exhibit G-1. A Proposed Rule for Hydrogen Control in Ice Condenser PWR's and Mark III BWR's was published in the Federal Register later that month.

Research at Sandia, TVA, and Duke Power, among others, continues. Berman issued a set of workshop proceedings in September 1981 dealing with hydrogen combustion and reactor safety. Rulemaking on degraded core accidents is underway.

In July 1982, the Commission completed its review of the hydrogen control system at McGuire and concluded that it could accommodate with adequate safety margins the hydrogen released in a 75 percent cladding-water reaction.

A Sandia study of hydrogen mitigation at Sequoyah concluded that, of the three mitigation schemes studied: deliberate ignition, water fogging, and Halon inerting; no one of them was clearly superior to the others under all accident scenarios. (41) The group also found that the possibility of developing uniform hydrogen concentrations in excess of 18 vol% seemed very remote.

McGuire-1's full power license was issued with a condition pertaining to hydrogen control, as was Sequoyah-1's. Both ice condenser units are equipped with a distributed ignition (glow plug) system (DIS), developed at Sequoyah. The DIS is designed to accommodate the S2D accident sequence, which is similar to

the TMI-2 accident, with up to 75 percent cladding-water reaction and a hydrogen release rate as high as 70 lb/min. The resultant peak combustion pressure is required to be less than the containment failure pressure, and the response to local detonations must be within the structural capacity of the containment. Peak temperatures are required to be less than that which would cause failure of certain essential equipment. All of these conditions must be met with adequate safety margins.

58484 Federal Register / Vol. 46, No. 231 / Wednesday, December 2, 1981 / Rules and Regulations

NUCLEAR REGULATORY COMMISSION

10 CFR Part 50

Interim Requirements Related to Hydrogen Control

AGENCY: Nuclear Regulatory Commission.

ACTION: Final rule.

SUMMARY: The Nuclear Regulatory Commission is amending its regulations to require inerted containment atmospheres, and additionally, both hydrogen recombiner capability to reduce the likelihood of venting radioactive gases following an accident and the provision of high point vents in the primary coolant system. The inerting requirement applies only to boiling water nuclear power reactors with either Mark I or Mark II type containments; the requirement for hydrogen recombiner capability applies to light-water nuclear power reactors that rely upon purge/repressurization systems as the primary means of hydrogen control; the requirement for the provision of high point vents applies to all light-water nuclear power reactors.

EFFECTIVE DATE: January 4, 1982.

FOR FURTHER INFORMATION CONTACT: Morton R. Fleishman, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, telephone 301-443-5981.

SUPPLEMENTARY INFORMATION: On October 2, 1980, the Nuclear Regulatory Commission published in the Federal Register (45 FR 65466) a notice of proposed rulemaking on "Interim Requirements Related to Hydrogen Control and Certain Degraded Core Considerations" (Interim Rule) inviting written comments or suggestions on the proposed rule by November 3, 1980. The notice concerned proposed amendments to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," to improve hydrogen management in light-water reactor facilities and to provide specific design and other requirements to mitigate the consequences of accidents resulting in a degraded reactor core.

Thirty-five persons submitted comments regarding the proposed amendments. Although the comment period was scheduled to expire on November 3, 1980, comments received subsequent to that date have been considered, with the latest comment letter being dated February 9, 1981. The comments are part of the public record and may be examined and copied in the Commission's Public Document Room at 1717 H Street NW., Washington, D.C. A summary of the comments along with a comment analysis and a value/impact assessment are also available for inspection and copying in the Public Document Room.

These comments have been carefully reviewed and evaluated during preparation of this final rule. The final rule contains revisions to the proposed rule that reflect these comments. The commenters were about equally divided between those in favor of and those opposed to publishing the interim amendments. Whether or not the commenter favored publishing a final rule, additional detailed comments were generally provided on specific aspects of the proposed amendments.

The NRC's Office of Nuclear Reactor Regulation sent a letter on September 5, 1980 to all nuclear power plant licensees, applicants and construction permit holders providing a "Preliminary Clarification of the TMI Action Plan Requirements." This was followed by a series of four regional meetings, noticed by publication in the Federal Register on September 12, 1980 (45 FR 60508) and held during the week of September 22, 1980, in order to provide a more detailed explanation of the requirements and to obtain industry comments. Based on the discussions at the meetings and other comments received, the NRC revised the requirements and notified the applicants, licensees and construction permit holders to this effect by a letter dated October 31, 1980. The letter and revised requirements are included in NUREG-0737, "Clarification of TMI Action Plan Requirements."[1]

On May 13, 1981, the Commission published in the Federal Register (46 FR 26491) a notice of proposed rulemaking which proposed licensing requirements for pending operating license applications (OL Rule). The proposed OL Rule was based upon the requirements described in NUREG-0737 and includes, among others, many of the requirements originally included in the proposed Interim Rule published in October 1980.

Items originally proposed in the Interim Rule were:

1. Inerting of Mark I and II boiling water reactors (BWRs).
2. Design analyses for Mark III BWRs and pressurized-water reactors (PWRs).
3. Dedicated hydrogen control penetrations.
4. Hydrogen recombiner capability.
5. High point vents
6. Post-accident protection of safety equipment and areas
7. In-plant iodine instrumentation
8. Post-accident sampling
9. Leakage integrity outside containment
10. Accident monitoring instrumentation
11. Detection of inadequate core cooling
12. Training to mitigate degraded core accidents

Of the above list, all except items 1, 2 and 4 were included in the proposed OL Rule and have been appropriately revised to reflect the comments received during the comment period on the proposed Interim Rule. Hence, those items included in the OL Rule have been deleted from this Interim Rule except for item 5 (High point vents). Item 5, while previously included in the OL Rule was felt to be primarily hydrogen related and thus more appropriately included in this Interim Rule. Those public comments received pertaining to the remaining OL Rule items will not be discussed here. All of the public comments may be examined and copied in the Commission's Public Document Room along with the response to the comments (SECY 81-245, "Interim Amendments to 10 CFR Part 50 Related to Hydrogen Control and Certain Degraded Core Considerations").

The final Interim Rule contains revisions to the proposed Interim Rule that reflect all of the applicable comments including those (a) given in response to the notice of proposed rulemaking, and (b) generated during the regional meetings and in response to the clarification letters of September 5, 1980 and October 31, 1980.

Before discussing the comments and the specific revisions resulting from the comments, it should be noted that, while § 50.44 has applied only to light-water nuclear power with zircaloy fuel cladding, the new amendments in the Interim Rule are not as limited and apply to light-water nuclear power reactors with either stainless steel or zircaloy fuel cladding. The Commission will be considering further modification of § 50.44 during the long-term rulemaking effort relative to consideration of degraded or melted cores in safety regulation. Part of this long-term rulemaking will involve a thorough reevaluation of hydrogen generation and control. In the interim, the Commission wishes to leave in place the existing provisions of § 50.44 because of the requirements for dealing with design basis accidents. These include, for example, requiring:

[1] Copies of this report may be obtained from GPO Sales Program, Division of Technical Information and Document Control, U.S.C. Nuclear Regulatory Commission, Washington, D.C. 20555.

Exhibit G-1

NRC Final Rule on Hydrogen Control

1. The capability for measuring hydrogen concentrations in containment.

2. The capability for ensuring a mixed atmosphere in containment.

3. The capability for controlling combustible gas concentrations in containment following a postulated LOCA.

4. The capability to deal with hydrogen from radiolytic decomposition of the reactor coolant and the corrosion of metals. (These have release characteristics that differ from those associated with metal-water reaction.)

5. That the combustible gas control systems conform with the general requirements of Criteria 41, 42 and 43 of Appendix A of 10 CFR Part 50.

Several commenters have expressed concern that the various rulemakings currently being pursued by NRC should be integrated, i.e., safety goal, degraded core considerations, minimum engineered safety features, siting and emergency planning. The NRC shares this concern. On October 15, 1980, the Executive Director for Operations established a Degraded Cooling Steering Group to coordinate degraded cooling and related rules. This group has completed its work and prepared a plan to ensure future integration of these activities.

Numerous commenters have questioned many of the implementation dates specified in the rule, indicating that they cannot be met for a variety of reasons, such as procurement lead time, need for the design studies, availability of acceptable equipment, etc. The staff agrees with these comments and has made appropriate changes to the implementation dates.

Inerting of Mark I and II BWRs [§ 50.44(c)(3)(i)]

Some commenters, particularly those associated with Mark I boiling water reactors (BWRs), questioned the advisability of requiring inerting of containments and suggested that other hydrogen control options be permitted. This issue has been extensively reviewed and discussed among the Commission, NRC staff and industry participants. Numerous reports and letters have been written and many meetings held in order to thoroughly air the issue. Considering the information previously developed, the Commission continues to believe that it would be prudent, pending completion of the long term rulemaking on degraded core cooling, to require that all Mark I and II BWR containments be provided with an inerted atmosphere during normal operations. However, one utility (Vermont Yankee) has recently expressed a renewed interest in providing a hydrogen control system, other than preinerting, for its facility. Two possible options, post-accident inerting and a deliberate ignition system, could be considered for the Mark I containment of this facility. The Commission has not received any specific proposal or analyses for either of these hydrogen control systems. Thus, it is concluded that, absent any proposed and justified alternative, preinerting is required for Mark I BWRs. If Vermont Yankee (or others) propose an alternative system backed up by suitable tests and analyses, the Commission will review it. If found acceptable, the alternative systems would be permitted, either by subsequent amandment or exemption to this section.

The proposed rule's deadline for installation of inerting systems has been extended to account for delay in publication of a final rule. The rule has also been changed to clarify that the paragraph applies only to Mark I and II BWRs.

Hydrogen Recombiner Capability [§ 50.44(c)(3)(ii)]

Several commenters have recommended that tha proposed § 50.44(c)(3)(ii) be modified to allow the use of alternate means of hydrogen control, such as internal recombiners, rather than to restrict the rule to external recombiners. The proposed rule was not intended to preclude this alternative. In fact, if internal recombiners were present before or will be installed in the future, this section of the rule would not apply since purge/repressurization systems would not be the primary means for combustible gas control. This section of the rule only applies to facilities that rely upon purge/repressurization systems as the primary means of controlling combustible gases following a LOCA. Based on existing § 50.44, all facilities must have either internal or external recombiners or purge/repressurization systems for controlling combustible gases following a LOCA. For those BWRs which are inerted and which rely upon purge/repressurization for combustible gas control, the intent of the rule is to require that they be provided with either internal recombiners or the capability to install external recombiners.

It should also be noted that this section of the rule does not require actual installation of external recombiners; rather, it requires only the capability for installation. To avoid confusion, the rule has been clarified to indicate that internal recombiners are an acceptable alternative to the installation of external recombiner capability.

High Point Vents in Reactor Coolant System [§ 50.44(c)(3)(iii)]

A number of commenters have remarked that there is no justification for applying the single failure criterion to the design of the high point vents. Furthermore, it has been suggested that the negative aspects of the high point vents have not been adequately considered and that, in fact, the vents may increase the risk to the public.

In response to these comments, the single failure criterion requirement has been deleted; however, one aspect of the criterion has been retained, namely, that a single failure within the power and control parts of the reactor coolant vent system should not prevent isolation of the entire vent system when required. Also a sentence has been added to require that the use of the high point vents not "aggravate the challenge to the containment or the course of the accident." Finally, the Interim Rule has been revised to relax the implementation date, in response to comments received at regional meetings with industry in September 1980.

Regulatory Flexibility Act

In accordance with the Regulatory Flexibility Act of 1980, 5 U.S.C. 605(b), the Commission hereby certifies that this rule will not, if promulgated, have a significant economic impact on a substantial number of small entities. This rule affects only the licensing and operation of nuclear power plants. The companies that own these plants do not fall within the scope of the definition of "small entities" set forth in the Regulatory Flexibility Act or the Small Business Size Standards set out in regulations issued by the Small Business Administration at 13 CFR Part 121. Since these companies are dominant in their service areas, this rule does not fall within the purview of the Act.

Accordingly, notice is hereby given that, pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974, as amended, and section 553 of Title 5 of the United States Code, the following amendments to 10 CFR Part 50 are published as a document subject to codification.

PART 50—DOMESTIC LICENSING OF PRODUCTION AND UTILIZATION FACILITIES

1. The authority citation for Part 50 reads as follows:

Authority: Secs. 103, 104, 161, 182, 183, 189, 68 Stat. 936, 937, 948, 953, 954, 955, 956, as

Exhibit G-1

Final Rule (cont.)

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amended (42 U.S.C. 2133, 2134, 2201, 2232, 2233, 2239); secs. 201, 202, 206, 88 Stat. 1243, 1244, 1246 (42 U.S.C. 5841, 5842, 5846), unless otherwise noted. Section 50.78 also issued under sec. 122, 68 Stat. 939 (42 U.S.C. 2152). Sections 50.80–50.81 also issued under sec. 184, 68 Stat. 954, as amended; (42 U.S.C. 2234). Sections 50.100–50.102 issued under sec. 186, 68 Stat. 955; (42 U.S.C. 2236). For the purposes of sec. 223, 68 Stat. 958, as amended; (42 U.S.C. 2273), § 50.54(i) issued under sec. 161i, 68 Stat. 949; (42 U.S.C. 2201(i)). §§ 50.70, 50.71 and 50.78 issued under sec. 161o, 68 Stat. 950, as amended; (42 U.S.C. 2201(o)) and the laws referred to in Appendices.

2. Section 50.44 of Part 50 is amended by revising paragraph (c) to read as follows:

§ 50.44 Standards for combustible gas control system in light water cooled power reactors.

* * * * *

(c)(1) For each boiling or pressurized light-water nuclear power reactor fueled with oxide pellets within cylindrical zircaloy cladding, it shall be shown that during the time period following a postulated LOCA but prior to effective operation of the combustible gas control system, either: (i) An uncontrolled hydrogen-oxygen recombination would not take place in the containment; or (ii) the plant could withstand the consequences of uncontrolled hydrogen-oxygen recombination without loss of safety function.

(2) If the conditions set out in paragraph (c)(1) of this section cannot be shown, the containment shall be provided with an inerted or an oxygen deficient atmosphere in order to provide protection against hydrogen burning and explosions during the time period specified in paragraph (c)(1) of this section.

(3) Notwithstanding paragraphs (c)(1) and (c)(2) of this section:

(i) Effective May 4, 1982 or 6 months after initial criticality, whichever is later, an inerted atmosphere shall be provided for each boiling light-water nuclear power reactor with a Mark I or Mark II type containment; and

(ii) By the end of the first scheduled outage beginning after July 5, 1982 and of sufficient duration to permit required modifications, each light-water nuclear power reactor that relies upon a purge/repressurization system as the primary means for controlling combustible gases following a LOCA shall be provided with either an internal recombiner or the capability to install an external recombiner following the start of an accident. The internal or external recombiners must meet the combustible gas control requirements in paragraph (d) of this section. The containment penetrations used for external recombiners must either be:

(A) dedicated to that service only, conform to the requirements of Criteria 54 and 56 of Appendix A of this part, be designed against postulated single failures for containment isolation purposes, and be sized to satisfy the flow requirements of the external recombiners, or

(B) of a combined design for use by either external recombiners or purge/repressurization systems and other systems, conform to the requirements of criteria 54 and 56 of Appendix A of this part, be designed against postulated single failures both for containment isolation purposes and for operation of the external recombiners or purge/repressurization systems, and be sized to satisfy the flow requirements of the external recombiners or purge repressurization systems.

(iii) To provide improved operational capability to maintain adequate core cooling following an accident, by the end of the first scheduled outage beginning after July 1, 1982 and of sufficient duration to permit required modifications, each light-water nuclear power reactor shall be provided with high point vents for the reactor coolant system, for the reactor vessel head, and for other systems required to maintain adequate core cooling if the accumulation of noncondensible gases would cause the loss of function of these systems. (High point vents are not required, however, for the tubes in U-tube steam generators.) The high point vents must be remotely operated from the control room. Since these vents form a part of the reactor coolant pressure boundary, the design of the vents and associated controls, instruments and power sources must conform to the requirements of Appendix A and Appendix B of this part. In particular, the vent system shall be designed to ensure a low probability that (A) the vents will not perform their safety functions and (B) there would be inadvertent or irreversible actuation of a vent. Furthermore, the use of these vents during and following an accident must not aggravate the challenge to the containment or the course of the accident.

* * * * *

Dated at Washington, D.C. this 25th day of November 1981.

For the Nuclear Regulatory Commission.

Samuel J. Chilk,

Secretary of the Commission.

[FR Doc. 81-34667 Filed 12-1-81; 8:45 am]

BILLING CODE 7590-01-M

Exhibit G-1

Final Rule (cont.)

CHRONOLOGY - THE CONSTRUCTION AND LICENSING OF McGUIRE

September 1970	Duke tenders applications for McGuire construction permits.
April 1971	Site preparation begins for the McGuire-Unit 1 reactor building.
September 1972	Crews begin work on the McGuire-1 reactor building.
February 1973	NRC issues McGuire construction permits.
February 1974	Work begins on the McGuire-1 turbine building condenser.
April 1974	Duke tenders applications for McGuire operating licenses.
September 1974	Crew begin installing the ice condenser inside the McGuire reactor building, and assembly of the McGuire-1 turbine begins.
October 1974	The first of four reactor building steam generators and reactor vessel is installed in McGuire-1.
February 1978	Three million pounds of ice is installed in the McGuire-1 ice condenser.
December 1978	Hot functional testing begins at McGuire-1.
March 1979	Three Mile Island-Unit 2 suffers a major accident.
July 1980	The second hot functional test is carried out at McGuire-1, and additional tests are performed on TMI-2 related modifications made to the unit.
December 1980	Hydrogen igniter system is installed at McGuire-1.
January 1981	Fuel assembly loading begins at McGuire-1.
February 1981	Re-opened public hearings on hydrogen generation begin.
June 1981	McGuire-1 receives its license to operate.
December 1981	Final version of hydrogen igniter system completed.

Instructor's Notes

This is one of a series of cases written to provide students with an opportunity to see how public policy decisions affect the engineering design process. This particular case focuses on the regulatory environment within which the designers of nuclear power plants operate.

There are several modes of using this case; much is deliberately left to the instructor's choice. This increases the flexibility of the case and allows its use in more than one type of course. There is more than enough technical material to permit the case to be used as a resource in a course in power plant design. Also, selected excerpts of those portions of the case dealing with the hydrogen control problem may be a useful way to amplify technical material normally covered in chemical thermodynamics or combustion courses.

Regardless of the specific matter in which the case is used, the student who has gone through it should have some feel for the problems of defining and managing a major engineering project in a complicated and rapidly changing regulatory climate.

The case also reveals that engineers cannot isolate themselves from the regulatory process and confine their attention to strictly technical matters. The technical and regulatory issues overlap to such a degree that the engineer becomes an integral part of the regulatory process.

Following are some suggestions for possible assignments, projects, exam questions, and discussion topics associated with various aspects of this case.

INTRODUCTION

1. What are the main design parameters for an ice condenser containment system?

2. What is the role of the Atomic Safety and Licensing Board? How is it related to the Advisory Committee on Reactor Safeguards mentioned in Part A?

PART A: NRC RESPONSE TO TMI-2

1. Exhibits A-1 and A-2 can be the basis for a detailed technical discussion of the PWR hydrogen detonation issue.

2. Obtain copies of SECY-80-107, 107A and 107B and try to verify the analytic basis for the conclusions on page nine i.e. ice condenser containments.

PART B: DUKE POWER COMPANY'S RESPONSE TO TMI-2

1. On the basis of the material included in the case and in the background documents, prepare a memo to Bill Rasin recommending a specific course of action regarding hydrogen control at McGuire.

PART C: PREPARATIONS FOR THE HEARINGS

1. Outline an approach to the analysis which would demonstrate that the deliberate ignition system would adequately prevent hydrogren accumulation.

PART D: THE LICENSING HEARINGS

1. Assume that you were Bill Rasin. Prepare your written opening testimony in response to the CESG contentions.

2. If you were a member of the ASLB, what decision would you reach after having heard the testimony of CESG and Duke? What would be the major factors affecting your decision?

PART E: THE LICENSING BOARD'S DECISION

1. Obtain a copy of Berman's report on hydrogen control measurements (NUREG/CR-1762 SAND 80-2714) and write a two-page memo to your boss at Duke, Bill Rasin, summarizing the report's implications for the McGuire licensing decision.

PART F: THE COMMISSIONER'S DECISION

1. Do you find the dissenting arguments of Commissioners Gilinsky and Bradford convincing?

2. Determine the current status of the McGuire-1 unit.